Before the
Federal Communications Commission
Washington, D.C. 20554

In the Matter of	)	
	)	
Advanced Television Systems	)	
and Their Impact upon the	)	MM Docket No. 87-268
Existing Television Broadcast	)	
Service	)	

COMMENTS OF THE
UNITED STATES ADVANCED TELEVISION SYSTEMS COMMITTEE
(ATSC)

The United States Advanced Television Systems Committee (hereinafter "ATSC") hereby files comments on the Memorandum Opinion and Order/Third Report and Order/Third Further Notice of Proposed Rule Making released October 16, 1992 ("Third Report/Third Notice").

The ATSC was established in late 1982 by the Joint Committee on Inter-Society Coordination (JCIC) to coordinate and develop voluntary national technical standards for advanced television systems. The JCIC members — the Electronic Industries Association, the Institute of Electrical and Electronics Engineers, the National Association of Broadcasters, the National Cable Television Association, and the Society of Motion Picture and Television Engineers — are Charter Members of the ATSC. More than fifty corporations, companies, television networks, associations and universities are also members of the ATSC and cooperate in the work of the organization. As such, the ATSC is broadly representative of virtually all facets of the United States television, motion picture, and electronics industries on the specific topic of Advanced Television (ATV). ATSC has participated in this Docket for the past five years.

In these comments ATSC will address selected actions taken by the Commission and certain other issues on which the Commission is now seeking comment.[1] Specifically:

- Endorsement of the ATSC plan for documentation of technical specifications once an ATV standard is selected.

- Encouragement of the efforts of the Advisory Committee to address any new audio developments.

- Direction to the Advisory Committee to monitor developments in Coded Orthogonal Frequency Division Multiplex technology.

- Comment sought on whether there is any necessity to exercise authority under the All Channel Receiver Act to require manufacturers to produce receivers capable of both NTSC and ATV reception.

- Comment sought on whether future advances in technology should be permitted on the conversion channel.

- Comment sought on whether to permit the use of ATV channels for ancillary purposes.

- Compatibility with other video delivery media.

ATV System Documentation of Technical Specifications

The ATSC work toward documentation of the technical specifications of the recommended ATV system has been continuing in recent months. Attachment A to these comments is the Report of ATSC Specialist Group T3/S1 which was approved by the Technology Group on Distribution on November 20, 1992 and by the ATSC Executive Committee on December 8, 1992. The document identifies system characteristics that we believe should be included in documentation of the ATV system when it is selected by the FCC. System Characteristics are listed in four categories: Source Coding, Data Multiplex and Channel Coding, RF/Transmission, and Receivers. The ATV System Documentation Guidelines shows the entity that will be the source for the information pertaining to each system characteristic and identifies the document or organization that is expected

[1] Third Report/Third Notice at paras. 6, 7, 76, 77, and 79 through 83. ATSC is not commenting at this time on certain other issues raised by the Third Report/Third Notice as those issues are being satisfactorily addressed by the group most directly affected; i.e., the broadcasters.

to provide documentation of that characteristic. In those cases where the FCC is listed, it is anticipated that the ATSC will perform the documentation task — submitting its results to the Commission.

Until the Advisory Committee on Advanced Television Service (Advisory Committee) recommends a specific system and until full technical details are available, the attached list is, of necessity, tentative. It may contain characteristics that do not apply to the chosen system, and it may be missing characteristics that do apply. Also, to provide flexibility for future improvements, the degree to which each characteristic is specified in the standards will need careful consideration. It is anticipated that the actual work on the ATV System Documentation will be carried out after the date on which the Advisory Committee decides on its recommended system but in time for the documentation to be considered by the Commission prior to its final decision on the selected system.[2]

Audio Developments

The Commission is correct when it states that the Advisory Committee is in the process of addressing new audio developments and the ATSC proposals for flexible use of audio and data. At the direction of the Chairman of the Advisory Committee, each proponent has considered, in the context of "system improvements", how it can meet the ATSC proposals. During the period when the ATSC will be documenting the recommended ATV system, we will have an opportunity to revisit this issue specifically for the selected system. This matter will be fully reported to the Commission by the ATSC as outlined in Attachment A.

Coded Orthogonal Frequency Division Multiplex Technology

The Commission was correct to direct the Advisory Committee to monitor the developments in the technology known as Coded Orthogonal Frequency Division Multiplex (COFDM). At the time comments were filed in the Second Report/Further Notice, this spread-spectrum technology had just been exhibited in connection with digital television development, especially in Europe. However, in the intervening months, we have learned new information about this technology and especially about its possible usefulness in the United States. Some of the proponents considered the use of COFDM as they were developing their own systems and rejected its use. Additionally, the Advisory Committee has gathered information which seems to mitigate against the use of COFDM in our marketplace.

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[2] The Commission noted that ISWP2 offered suggestions to the ATSC concerning the timely documentation of the ATV standard. (Third Report/Third Notice at footnote 301.) The Commission may be assured the suggestions were taken into consideration during the work of T3/S1 as reflected in Attachment A.

The Advisory Committee continues to review developments in this area and the Commission may be assured that it will learn all pertinent information concerning COFDM prior to the time it chooses the winning ATV system for the United States. Further information on this matter has been documented by the Advisory Committee's OFDM Study Group in a report dated October 23, 1992. The same Study Group also filed a supplementary report to the Advisory Committee on November 5, 1992.

All Channel Receiver Act

Television receiver manufacturers will likely introduce advanced television to the public through "high end" equipment. At the time that equipment is sold initially, most television programming will continue to be delivered in the NTSC format...not in the new ATV format. We believe there is no chance that equipment manufacturers who are seeking purchasers for this comparatively expensive product would leave out the ability of that equipment to receive the most prevalent format for American television; NTSC.

It is clearly not necessary for the Commission to regulate in this area. Set manufacturers will provide the proper equipment for the market.

Compatible Future Advances in Technology and Ancillary Uses of the ATV Channel

The Commission must permit "other types of advanced technology uses on the ATV channel".[3] In fact, as we move into the age of digital television, the use of largely unknown advanced technologies may become the most valuable use of this new medium. It is clearly impossible at this time to project what those technologies might be; they have not been invented yet! It is for this reason that considerable efforts are being expended on the matter of adding "headers and descriptors" to the transmitted signals.

If all works as expected, advanced television receivers may well be able to configure themselves to display whatever is transmitted. And, unlike the difficulty with implementation costs experienced by equipment manufacturers during the time of analog television, it may well be that the cost of providing advanced technologies in a digital television receiver is negligible. This situation prevails because the receiver itself already contains an enormously large computing capability; and, it is anticipated that the standards documentation will be carried forth with a view toward establishing flexible and interoperable standards that will readily permit future — but currently unknown — uses.

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[3] Third Report/Third Notice at para. 76.

Perhaps most important, television broadcasters may need alternative revenue streams to enable them to invest the millions of dollars that will be required in order to implement a whole new infrastructure of television for the American public. Therefore, it is extremely important to not preclude the development of such alternative uses at this time. In most respects, the technical phase of the selection of an advanced television system is complete. We are now moving to the economic phase of implementation. Alternative technology uses of the ATV channel may hold the solutions for rapid but economic implementation of a whole new television system for the United States.

In a similar area of Commission inquiry, the ATSC believes that similar arguments can be made to permit technical flexibility concerning ancillary uses of the ATV channel. Maximum flexibility must be provided to broadcasters in these very important matters and no decisions should now be reached which would preclude inventive and expansive use of the new channels, so long as those uses do not diminish the primary purpose for which the channels are being authorized...that is, for delivery of High Definition Television.

Compatibility with Other Video Delivery Media

Attachment B to these comments is a report of the ATSC Specialist Group on Interoperability and Consumer Product Interface - T3/S2. This report was adopted by the Technology Group on Distribution on November 20, 1992 and by the Executive Committee on December 8, 1992. T3/S2 has been working for more than three years studying issues relating to interoperability among the various media that may be employed to deliver advanced television service to United States Consumers and the resulting impact on the interface between consumer products and the various media.[4]

The various recommendations contained in Attachment B will be distributed to all appropriate parties, including the Advisory Committee. It would now seem clear that there are no insurmountable obstacles to the delivery of the proposed digital advanced television systems by all known alternative media. Digital television is simply "more interoperable" than is analog television.

Closing

Finally, the United States Advanced Television Systems Committee continues to work diligently with the Commission and with the Advisory

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[4] Besides terrestrial broadcast, the other media, often referred to as "alternate media", include cable television, Direct Broadcast Satellite, switched broadband fiber optic links, and pre-recorded media such as video tape and video disc.

Committee to assure that a successful conclusion is reached in the matter of providing High Definition Television and other compatible technologies to the American public at the earliest possible date. We will continue to supplement the record in this proceeding with appropriate reports and findings as they become available.

Respectfully submitted,

United States Advanced Television Systems Committee
1776 K Street NW, Suite 300
Washington, DC 20006

James C. McKinney
Chairman

December 15, 1992

Attachment A

Doc. T3/210
20 Nov 1992

Advanced Television Systems Committee
T3/S1 Specialist Group on Macro Systems Approach

ATV SYSTEM DOCUMENTATION GUIDELINES

Introduction

On June 5, 1992, ATSC provided information to the FCC outlining proposed industry actions to fully document the advanced television standard. Supporting this activity, the ATSC Executive Committee requested that the T3/S1 Specialist Group on Macro Systems Approach meet and suggest which portions of an ATV broadcasting standard should be incorporated into the FCC Rules and which portions should be voluntary. Subsequently, T3/S1 held meetings on July 24, August 13, September 11 and October 27, 1992. Recommendations were developed in two areas:

1. Principles upon which documentation of the ATV standard should be based; and

2. A list of characteristics of an ATV system that should be documented. The list tentatively identifies the industry group(s) that would provide the documentation information as well as identifying the standards document where the information would likely appear.

These recommendations, as developed in the T3/S1 Specialist Group and modified at the November 20 meeting of the T3 Technology Group, are shown below.

1. Principles for Documenting the ATV Standard

1. The selected ATV system proponent must be the principal supplier of information for documenting the ATV standard with support from ATSC and others.

2. Advance determination of FCC requirements for the ATV standard should be obtained as soon as possible.

3. Complete functional system details (permitting those skilled in the art to construct a working system) should be publicly available; however, details of specific system implementations may be proprietary. Protection of any proprietary content must be by patent or copyright as appropriate.

4. System specifications should explain how compatible improvements are to be achieved, whether through the use of a header-and-descriptor structure or by other means.

5. The ATV standard should include the necessary system information such that ATV encoders may be manufactured to deliver the system's full demonstrated performance quality.

6. The current level of technical disclosure from proponents is not adequate for the task of documenting the ATV standard for the FCC and the television industry. Proponents are encouraged to begin drafting the essential elements of system details as soon as possible to avoid delays in producing the ATV standard documentation.

7. The ATV standard must guarantee backward compatibility of future improvements with all generations of ATV receivers and inherently support production of lowest cost receivers (notwithstanding that cost reduction through reduced performance quality may also be used to achieve inexpensive products.)

8. The ATV standard should not foreclose flexibility in implementing ATV receivers at different price and performance levels.

9. As ongoing improvements take place in the ATV system, manufacturers of encoders and decoders should coordinate their efforts to insure compatibility.

2. List of System Characteristics to be Documented in the ATV Standard

System characteristics are listed in four categories: Source Coding, Data Multiplex and Channel Coding, RF/Transmission, and Receivers. Most of the characteristics have sub-characteristics listed underneath them, showing examples of details that should be included in fully documenting the associated system characteristic. The list shows also the entity that will be the source for the information pertaining to each system characteristic and identifies the document or organization that is expected to provide documentation of that characteristic. Until a system is chosen and full technical details are available, this list is, of necessity, tentative. It may contain characteristics that do not apply to the chosen system, and it may be missing characteristics that do apply. Also, to provide flexibility for future improvements, the degree to which each characteristic is specified in the standards will need careful consideration. Note that where the FCC is listed, it is anticipated that ATSC will perform the documentation task.

System Characteristic	Information Provider	Standardization Document
Source Coding		
Input source format	proponent	SMPTE/FCC Rules
aspect ratio		
number of vertical scanning lines		
sequence of line scanning		
number of bits per pixel		
sampling rate		
anti-aliasing		
Input colorimetry/transfer characteristics/pre-processing	proponent	SMPTE/FCC Rules
pre/post processing filter		
color conversion matrix		
color decimation filter and filter factors		
chroma interpolation filter		
Compression algorithm	proponent	FCC OET Bulletin
internal DCT word length		
accuracy of DCT coefficients		
classified DCT		
fast DCT algorithm		
Quantizer/inverse quantizer	proponent	FCC OET Bulletin
number of tables		
adaptive step size		
adaptive quantization		
human visual system weighting		
adaptive bit allocation		
dynamic range		
DPCM prediction loop	proponent	FCC OET Bulletin
predictor coefficients		
refresh interval		
leak factor and adaptation		
inter/intra frame switching		
Variable length coder/decoder	proponent	FCC OET Bulletin
number of look-up tables		
adaptive table generation algorithm		
initialization routine		
Motion estimation	proponent	FCC OET Bulletin
motion vector search algorithm		
motion search range		
number of storage frames		
number of motion vectors		
components used for search		
motion vector encoding		
vector search accuracy		
Buffer rate controller	proponent	FCC OET Bulletin
quantizer bit allocation		
components multiplexing		
Audio transform coding compression	proponent	FCC OET Bulletin
transform window size		
number of transform bands		
psychoacoustic model		
dynamic bit allocation model		
spectral envelope shape		
Maximum coding delay	proponent	FCC Rules
Total acquisition time	manufacturer	

System Characteristic	Information Provider	Standardization Document
Data Multiplex and Channel Coding		
Audio services	proponent	FCC
main program multi-channel audio modes		
3/2 ch. program		
3/0 ch. program		
2/0 ch. program		
language multi-channel audio modes		
3/2 ch. program		
3/0 ch. program		
2/0 ch. program		
independently coded channels		
program for visually impaired		
program for hearing impaired		
2/0 ch. stereo main program		
2/0 ch. language program		
audio control		
headroom		
dynamic range		
user bits		
language		
Captioning service	EIA	FCC Rules
Teletext service	EIA	EIA
Program guide service	EIA	EIA
Program and source identification service	EIA	EIA
Other services	TBD	TBD
Conditional access control information	proponent	NCTA/EIA
encryption		
key management		
scrambling		
addressability		
Bit stream syntax	proponent	FCC Rules
sync		
equalization/ghost canceling training sequence		
channel error protection (location)		
channel error protection specification/control data		
block/segment numbering/ordering		
information prioritization		
video data		
quantization tables and coefficients		
motion vectors		
YUV multiplexing; luminance and chrominance blocks		
motion compensation processor		
macroblocks		
spatial transform size and shape		
frame type		
group of pictures		
intra/inter frame		
leak factor		

System Characteristic	Information Provider	Standardization Document

- audio multiplexing
  - main program multi-channel audio modes
    - 3/2 ch. program
    - 3/0 ch. program
    - 2/0 ch. program
  - language multi-channel audio modes
    - 3/2 ch. program
    - 3/0 ch. program
    - 2/0 ch. program
  - independently coded channels
    - program for visually impaired
    - program for hearing impaired
    - 2/0 ch. stereo main program
    - 2/0 ch. language program
  - audio control
    - headroom
    - dynamic range
    - user bits
    - language
- data multiplexing
  - captioning
  - program and source identification
  - conditional access control information
  - non-program data
    - program guide
    - teletext
    - reserved/test/service data
    - other data
- headers/descriptors/data type identifiers
  - channel error protection (location)
  - channel error protection specification/control data
  - block/segment numbering/ordering
  - information prioritization
  - video data
    - quantization tables and coefficients
    - motion vectors
    - YUV multiplexing; luminance and chrominance blocks
    - motion compensation processor
    - macroblocks
    - spatial transform size and shape
    - frame type
    - group of pictures
    - intra/inter frame
    - leak factor

System Characteristic	Information Provider	Standardization Document
audio multiplexing		
main program multi-channel audio modes		
3/2 ch. program		
3/0 ch. program		
2/0 ch. program		
language multi-channel audio modes		
3/2 ch. program		
3/0 ch. program		
2/0 ch. program		
independently coded channels		
program for visually impaired		
program for hearing impaired		
2/0 ch. stereo main program		
2/0 ch. language program		
audio control		
headroom		
dynamic range		
user bits		
language		
data multiplexing		
captioning		
program and source identification		
non-program data		
program guide		
teletext		
reserved/test/service data		
other data		
Channel error protection	proponent	FCC Rules
forward error correction		
convolutional coding		
linear block coding		
data interleaving		
depth of interleaving		
block		
convolutional		
channel multiplexing		
concatenated coding		
trellis/set partition modulation codes		
RF/Transmission		
Allotment/Assignment	FCC	FCC Rules
table of allotments/assignments		
basis for channel assignments		
power and antenna height limits		
prediction of coverage		
Modulation	proponent	FCC Rules
modulation method		
carrier/subcarrier frequencies/relative levels		
number of bits per symbol		
bit and frame sync recovery		

System Characteristic	Information Provider	Standardization Document
Transmitter	TBD	FCC Rules
transmitter pulse shape (matched filter)		
output power requirements		
spectral mask requirements		
frequency stability		
phase stability		
spurious response		
Test and Monitoring	IEEE	FCC Rules
power measurement method		
monitoring equipment		
compliance methods		
Receivers		
Noise figure	EIA	EIA
Adjacent channel rejection	EIA	EIA
Taboo rejection	EIA	EIA
Antenna gain measurement method	EIA	EIA
Antenna front-to-back ratio measurement method	EIA	EIA
Direct pick-up	EIA	EIA/FCC?
Adaptive equalizer	manufacturer	EIA guideline?
speed of adaptation		
number of taps and precision		
adaptation algorithm		
equalization range		
tap spacing		
training sequence		
Error detection and correction	manufacturer	
error detection method		
maximum correction range		
coding gain at threshold		
Error concealment	proponent	EIA guideline?
header parameters		
tables		
DCT coefficients		
sync recovery		
slice recovery		
motion vectors		
audio dropout		
Local oscillator radiation	EIA	FCC Part 15
IF frequencies	EIA	EIA
other local oscillator requirements		
heterodyne technique		
tuner return loss		
bandpass spectrum		
AGC	manufacturer	
AFC	manufacturer	
Post reconstruction filter	manufacturer	
Consumer interface standards	NCTA/EIA	NCTA/EIA/FCC
Caption presentation (display) system	EIA	EIA/FCC
Conditional access	proponent	NCTA/EIA
Other services	TBD	TBD

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Attachment B

Doc. T3/217
8 Dec 1992

INTEROPERABILITY AMONG ALTERNATE MEDIA FOR THE DELIVERY OF ADVANCED TELEVISION PROGRAMMING AND RELATED CONSUMER PRODUCT INTERFACE ISSUES

FINAL REPORT

of ATSC Specialist Group on Interoperability
and Consumer Product Interface
(T3/S2)

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INTEROPERABILITY AMONG ALTERNATE MEDIA FOR THE DELIVERY OF ADVANCED TELEVISION PROGRAMMING AND RELATED CONSUMER PRODUCT INTERFACE ISSUES

FINAL REPORT

of ATSC Specialist Group on Interoperability
and Consumer Product Interface
(T3/S2)

EXECUTIVE SUMMARY

The Specialist Group on Interoperability and Consumer Product Interface (T3/S2) was created by the ATSC Technology Group on Distribution (T3) to study issues relating to interoperability among the various media that may be employed to deliver Advanced Television (ATV) service to U.S. consumers, and to study the resulting impact on the interface between consumer products and the various media. Besides terrestrial broadcast, the other media considered include Cable Television, Direct Broadcast Satellite (DBS), "wired" alternatives to Cable TV, e.g., switched broadband fiber optic links, and pre-recorded media. An early conclusion was that the requirements for interoperability and consumer product interface would be most easily met if all media were to adopt substantially the same baseband video signal format.

A major portion of the work of T3/S2 was concentrated on scrambling, the means to control access to scrambled programming, and issues related to the development of a single conditional-access standard, including related TV receiver external interfaces. Other issues addressed by T3/S2 were plans to conduct satellite delivery tests of the proposed ATV systems; receiver control and communications interfaces; the importance of packaging transmitted data in an all-digital ATV system into segments which are identified by headers and descriptors; and the desirability of using the same basic compression algorithm and source-code format, as well as the same conditional-access standard, for delivering both HDTV and multiple 525-line TV signals.

T3/S2 makes the following specific recommendations with respect to interoperability and consumer product interface:

- All alternate media for the delivery of ATV programming should choose the same source-coding algorithm and baseband digital signal format chosen by the FCC for terrestrial broadcast.

- Alternate media should choose channel coding and modulation methods appropriate to the medium.

- Data services will vary from medium to medium. It is therefore extremely important that the transmitted digital data stream be divided into identifiable segments that can be flexibly assigned to video, audio and data services.

- The EIA should take to completion its work to develop a voluntary baseband bit-serial digital interface for ATV receivers and VCR's. This interface standard is an achievable key step to providing user friendliness and an important first step towards a voluntary conditional-access standard.

- Strong consideration should be given to developing a single voluntary conditional-access standard that could be adopted for use by all media, including terrestrial broadcast.

- The EIA should look to the day when part or all of the conditional-access hardware can be built into the ATV receiver or VCR and develop voluntary standards for the required receiver interfaces.

- The EIA should also develop a voluntary standard for a control interface (possibly based on CEBus) to provide communication between ATV receivers and VCR's and other peripheral devices.

- To achieve the necessary cooperation among industry segments to develop a single conditional-access standard, T3/S2 recommends that once the FCC has chosen a terrestrial broadcast ATV standard, the winning proponent should meet with representatives of the various transport media (Cable TV, DBS, etc.), manufacturers, and other interested parties to seek agreement on an appropriate conditional-access standard.

- This same group should include standards for digital NTSC transmission as part of its agenda and, to the extent possible, seek to achieve commonality of compression and modulation methods as well as conditional access.

I. INTRODUCTION

This Specialist Group was created in August of 1989 by the ATSC Technology Group on Distribution (T3) to study issues relating to interoperability among the various media that may be employed to deliver Advanced Television (ATV) service to U.S. consumers and to study the resulting impact on the interface between consumer products and the various media. Besides terrestrial broadcast, the other media, often referred to as alternate media, to be considered include Cable Television (Cable), Direct Broadcast Satellite (DBS), "wired" alternatives to Cable, e.g., switched broadband fiber optic links, and pre-recorded media, e.g., video tape and video disc. An objective of the Specialist Group is to develop a body of technical information relating to the requirements of the alternate media that the ATSC can provide to the FCC Advisory Committee on Advanced Television Service (ACATS) to assist in the choice of an ATV standard for terrestrial

broadcast. A further objective is to encourage the alternate media to adopt voluntary standards for transmission of ATV signals that will maximize the interoperability among media and especially between the alternate media and terrestrial broadcast. A final objective is to encourage the adoption of a voluntary interface standard by television receiver manufacturers that will accommodate the needs of the alternate media. The goal is to achieve a set of harmonized standards that are friendly to the various delivery media and the consumer.

A. Charter

At the September 15, 1989 meeting of T3/S2, we adopted a Charter and Statement of Goals and Objectives (Document T3S2/003) that was subsequently approved by T3 on September 18, 1989.

B. Membership

The membership of T3/S2 totals approximately 30 and includes a broad cross-section of the television industry with representation from broadcasters, receiver manufacturers, programmers, the telephone industry, Cable TV operators and equipment manufacturers, ATV system proponents, satellite operators and equipment manufacturers, etc. Bernard J. Lechner (Consultant[1]) serves as Chairman, Joe Waltrich (General Instrument) served as Secretary through our July 18, 1990 meeting and Bob Burroughs (Panasonic) has been the Secretary starting with the August 20, 1990 meeting. Our membership list is contained in Document T3/218.

C. Chronology of Meetings

T3/S2 has held 25 meetings, all but one, in Washington, D.C. Typically we have 12 to 15 members attending each meeting.

August 3, 1989
September 15, 1989
November 1, 1989
January 18, 1990
March 7, 1990
April 19, 1990
Joint meeting with EIA-Multiport Receiver Subcommittee
April 20, 1990
May 23, 1990
At NCTA Convention in Atlanta, Georgia
July 18, 1990
August 20, 1990
October 9, 1990
December 5, 1990
January 15, 1991
April 3, 1991

[1] Mr. Lechner's participation was supported by Cable Television Laboratories through December, 1991 and since that time by the David Sarnoff Research Center.

May 13, 1991
July 2, 1991
August 12, 1991
October 3, 1991
November 12, 1991
January 9, 1992
March 10, 1992
June 10, 1992
July 21, 1992
September 10, 1992
October 16, 1992

D. Documents

In carrying out its work T3/S2 has considered/generated over 100 documents. A complete list of these documents in contained in Document T3/219.

II. BACKGROUND

As the United States moves toward the adoption of standards for a terrestrial broadcast ATV service, it is important to recognize that ATV services also will be provided by the alternate media. Since these media have differing needs as well as differing technical and regulatory constraints, it is important to insure coordination and cooperation among all media in the development of standards so that program material delivered by any one medium also can be easily delivered by all other media and so that consumer receivers can be easily interfaced to all possible media. If this is not done, expensive conversion equipment might be required to exchange programming between media and, worse yet, consumer television receivers might require complex, and potentially user-unfriendly, interface boxes to receive programs from the various alternate media.

This need has been recognized by the FCC and has been addressed in part by ACATS through the Planning Subcommittee Working Party 4 (PSWP4) on Alternate Media and the Systems Subcommittee Working Party 4 (SSWP4) on System Standards. Specifically, SSWP4 recognized the importance of Cable TV in delivering terrestrial broadcast signals to consumers and has explicitly stated that any standard(s) adopted for terrestrial broadcast must be capable of being transmitted over Cable TV systems. The HDTV Subcommittee of the National Cable Television Association (NCTA) Engineering Committee, PSWP4 and Cable Television Laboratories (Cable Labs) developed a basic test plan to evaluate the performance of proposed terrestrial-broadcast ATV systems when transmitted through Cable TV systems and over fiber optic links. Cable Labs converted this basic test plan into a specific series of tests, incorporated as part of the SSWP2 test plan, and installed the necessary Cable TV and fiber optic equipment at the Advanced Television Test Center (ATTC) where Cable Labs conducted tests of the proposed ATV systems.

Field tests are being planned by SSWP2 and will be conducted in Charlotte, North Carolina following completion of the tests at the ATTC and the Advanced Television

Evaluation Laboratory (ATEL) in Canada. The field tests will start after the recommendation of a system by ACATS.

An early activity of T3/S2 was to review the work previously done by PSWP4. PSWP4 provided us with a copy of its May 9, 1988 final report[2] containing a wealth of information that served as background material for our work and provided us with a point of departure.

In late 1988, PSWP4 developed a strawman proposal for an ATV Multiport receiver interface that would make it possible for ATV receivers to interface to alternate media sources. Subsequently the Electronics Industries Association (EIA) ATV Committee created an ATV Multiport Receiver Subcommittee. This Subcommittee, which is now a part of the EIA R-4 Engineering Committee (designated as the EIA Receiver Interface Subcommittee - R4.1), developed a detailed generic model of an ATV receiver showing a number of possible interfaces.

PSWP4 also had developed a test plan for satellite transmission, but at the outset of the work of T3/S2, there was no concrete plan to implement satellite transmission tests. However, the Satellite Broadcasting and Communications Association (SBCA) expressed interest in such a test program and some organizations volunteered to lend equipment for the tests.

It is in the context of these various related activities that T3/S2 undertook its work in August of 1989. To insure that there would be neither competition nor unnecessary duplication of effort, T3/S2 established and has maintained liaison with EIA, PSWP4, SSWP4, SBCA and NCTA.

III. ACTIVITIES OF T3/S2

A. General Approach

Early in its work, T3/S2 realized that the alternate media were free to choose ATV standards totally unrelated to those developed for terrestrial broadcast. We concluded that such a scenario was both unwise and unlikely, and in any event, unless and until some medium chose such a standard, there was little if anything we could do to deal with its interoperability with terrestrial broadcast and other media. Recognizing that the various media will employ different modulation methods and

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[2] In the fall of 1991 PSWP4 was reactivated, and starting on October 18, 1991, has held a series of meetings under expanded initiatives to examine the relationship of terrestrial advanced television systems to alternative media, applications and standards, in the broader context of recognized and anticipated advances in computing, communications and imaging technology.

may format and condition the signals for transmission differently, we concluded that the requirements for interoperability and consumer product interface would be most easily met if all media were to adopt substantially the same baseband video signal format. We made this statement intentionally vague to allow for the possibility that variations among media will allow exploitation of extra capability by a given medium or fitting within a constraint by another medium without unduly compromising interoperability or complicating the consumer product interface. As an example, the signal provided by VHS tape has less luminance bandwidth than broadcast NTSC, whereas the signal provided by S-VHS has more luminance bandwidth than broadcast NTSC. Yet both tape formats can interoperate with each other and with conventional NTSC receivers using either RF or baseband electrical interfaces. Of course, the full capability of S-VHS can be realized only with a receiver having a Y-C input jack. This is a clear example of interoperability and extensibility between differing, but related, standards.

Assuming that the standard chosen by the FCC for terrestrial broadcast of ATV would form the basis for the standards employed by the various alternate media, T3/S2 focussed on examining the standards proposed for terrestrial broadcast. We have attempted to evaluate how well each of the proposed terrestrial standards meets the unique needs of the alternate media with regard to interoperability and consumer friendliness.

To ensure that the context of our work would be properly understood, we adopted the following definitions for baseband video signal and interoperability:

- *Baseband Television Video Signal*

  - *Analog Baseband Television Signal*

    A signal whose amplitude as a function of time represents the video content of the television image. The signal is not modulated on a carrier, although it may contain subcarriers, e.g., the NTSC, PAL or SECAM color subcarriers.

  - *Digital Baseband Television Signal*

    A linear PCM digital representation of an analog baseband television signal. The signal is neither encoded nor is it modulated on a carrier.

- *Interoperability with Alternate Media*

  - *Interoperability of Consumer Television Devices*

    As applied to consumer television devices, including receivers, monitors, VCR's, etc., interoperability means the device can process and/or display television signals from a multiplicity of delivery media.

- *Interoperability Among Delivery Media*

  As applied to program interchange among various delivery media, interoperability means that video and audio program signals intended for delivery by a given medium can be easily transcoded for delivery by other media without loss in video or audio quality other than that imposed by the medium to which the signals are transcoded.

B. Cable Television and Conditional Access

T3/S2 decided initially to concentrate on Cable TV and to characterize the needs of Cable TV in an ATV environment. We agreed that most of the issues of concern to the Cable TV industry would be covered by the test program conducted by Cable Labs at the ATTC. The major issue that has not been covered by the Cable TV test plan is scrambling and the need for data transmission to control conditional access to scrambled programming. Since the data transmission for controlling access falls within the charter of the ATSC Specialist Group on Digital Services (T3/S3), starting with our January 18, 1990 meeting, T3/S2 has met jointly with T3/S3. Once again to ensure that the context of our work will be properly understood, we adopted the following definitions[3] of terms:

- *Conditional-Access System*

  Within a television distribution system, the means to selectively provide specific television programs to specific individual subscribers. The system includes means to track access for accounting purposes.

- *Scrambling*

  Alteration of the characteristics of a broadcast video/sound/data signal in order to prevent unauthorized reception of the information in a clear form. This alteration is a specified process under the control of the conditional-access system (sending end).

- *Descrambling*

  Restoration of the characteristics of a broadcast video/sound/data signal in order to allow reception of the information in a clear form. This restoration is a specified process under the control of the conditional-access system (receiving end).

Note 1: The terms scrambling and descrambling are applicable to both analog and digital signals.

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[3] These definitions are taken in large part from CCIR Document 11/BL/33-E dated 26 May 1992.

Note 2: The terms should not be used to describe processes such as energy dispersal in a satellite system.

- *Conditional-Access Control*

  The function of the conditional-access control at the sending end is to generate the scrambling control signals and the "keys" associated with the service.

  The function of the conditional-access control at the receiving end is to produce the descrambling control signals in conjunction with the "keys" associated with the service.

- *Encryption and Decryption*

  These are terms used for methods employed to protect (encrypt) and interpret (decrypt) some of the information within the access-related messages that are transmitted from the sending end of the conditional-access control to the receiving end of the conditional-access control.

At our March 7, 1990 meeting, we reviewed the criteria for scrambling and conditional access used by the Direct Broadcast Satellite Association (DBSA) in 1986 as well as a list of attributes generated by Graham S. Stubbs, the Chairman of T3/S3. Originally we reached a consensus on four basic desirable attributes for a scrambling and conditional-access system.

- *The images displayed on receivers not authorized to receive the scrambled programming must be unrecognizable.*

- *It must not be possible to recover the image by inspecting the transmitted signal and performing any reasonable processing on the information contained therein.*

- *The details of how the system operates must be assumed to be general public knowledge.*

- *The security of the system is entirely contained in the delivery and processing of the key.*

During subsequent joint meetings of T3/S2 and T3/S3, this list was modified and expanded and it was augmented by a second list of desirable features and other considerations. A first draft was mailed by T3/S3 to the ATV proponents and other interested parties in August of 1990. The comments received were incorporated into a second draft which was mailed by T3/S3 to a wide cross-section of the television industry in December of 1990. The final result was ATSC Document T3/180 dated 16 May 1991, which has been widely distributed to the ATV proponents and others for use as a guideline in developing and evaluating ATV systems. This document

was revised on 21 July 1992 to conform its terminology with the CCIR definitions listed above.

During 1990 T3/S2 solicited and received information from the ATV system proponents concerning how they planned to meet the original four basic desirable attributes for a scrambling and conditional-access system. This was at a point in time when most of the proposed systems were based on analog transmission. It was our hope that we could identify certain major aspects of a conditional-access system that would form the basis for a single voluntary industry standard.

As of December, 1990, when we issued our first status report (Document T3S2/047), we were unable to identify a basis for a single conditional-access standard for two principal reasons. First, with respect to scrambling of analog signals, the simple systems of sync suppression and/or video inversion did not satisfy the requirements of unrecognizable images and impossibility of recovery by inspection. The more complicated analog techniques of line rotation and/or permutation, although potentially capable of satisfying these requirements, were felt by many to be too expensive to implement. Also they might introduce artifacts in the descrambled images. The second reason was that no matter how sophisticated the conditional-access control function, sooner or later it would become known to a pirate who could then clone a legitimate receiver to breach the security of delivering and processing the keys.

We did, however, recognize that much of the confusion, cost and user unfriendliness that currently exists in the NTSC world could be eliminated if ATV receivers and VCR's were equipped with a standardized baseband signal interface. Such an interface would permit conditional-access and descrambling functions to be accomplished in a back-of-the-set box rather than a set-top converter. Eliminating the need for a set-top converter would lead to reduced cost, improved performance and greatly improved user friendliness. The existence of multiple conditional-access standards could require the use of multiple back-of-the-set boxes, but since the consumer does not need to interact directly with these boxes (as he must with a set-top converter), the user friendliness of the approach is preserved. Furthermore, should a single voluntary conditional-access standard emerge at some future time, some or all of the conditional-access hardware could be built into new ATV receivers and VCR's, while existing receivers and VCR's continued to need a back-of-the-set box.

C. The Emergence of Digital ATV

By January, 1991 a major change had occurred in the systems under consideration for an ATV terrestrial broadcast standard. Four of the five proposed full high-definition ATV simulcast systems were now based on digital transmission and it was immediately clear that they could easily meet the "unrecognizability" and "impossi-

bility of recovery by inspection" requirements for conditional access with simple hardware. The signal would be scrambled by performing a mathematical operation on the source-coded digital signal and a pseudo-random number. The usual technique is a bit-by-bit exclusive-OR operation, but there are other possibilities. The pseudo-random number can be generated by a feedback shift register supplied with a suitably large (>60 bits) seed, although again there are other possibilities.

The descrambling process performs the complementary mathematical operation (identical in the case of bit-by-bit exclusive-OR) on the received signal using the same pseudo-random number. To generate this number at the receiver requires that the receiver have the proper seed for its pseudo-random number generator.

At the sending end, the conditional-access system must process orders from subscribers, generate billing information and instruct the control function which subscribers are to be authorized by channel and time period. The conditional-access control function at the sending end generates the seed for the pseudo-random number generator and one or more associated keys. The keys are encrypted in accordance with a defined algorithm and transmitted to authorized subscribers as part of the digital data stream. An authorized receiver is able to decrypt the keys and generate the required seed. This process is based on hardware or firmware in the receiver to implement the decryption algorithm and requires that each receiver contain a unique "secret" number known only to the sender. It is this piece of the receiver system that is subject to attack by a pirate. If he can clone the hardware or firmware which implements the decryption algorithm including the "secret" number of a legitimate authorized subscriber, the system will be compromised. This is true even if the keys are distributed by some means other than transmitting them as part of the digital data stream, e.g., by mail. Alternate distribution complicates matters for the pirate since he must redistribute the keys to his "clients", but it also complicates matters and increases costs for the service provider, and it does not protect the system from a breach of security.

Although the above discussion has focussed on video, the audio and data portions of the transmitted digital signal obviously can be scrambled also, either simultaneously with the video or separately if desired, e.g., audio and data services marketed separately.

During 1991, T3/S2 studied the above issues. We invited ATV system proponents and others to present their views at our meetings. During these presentations the concept of a replaceable security module was put forth as a way to deal with cloning by a pirate. If the hardware or firmware that implements the decryption algorithm and contains the "secret" number is configured as an easily replaceable module, it can be readily changed if and when a pirate has made a successful attack on the system. The fact that it can be so easily replaced, or for that matter, that it may be routinely replaced on a periodic basis, is in itself a strong